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Mathematical Modeling, Analysis, Simulation of the Opioid Crisis with Prescription and Social Drug Addiction Models

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According to the Centers for Disease Control, opioid overdose rates are rising, and data suggests that both prescription and illicit drugs are significant with respect to the opioid crisis. This is an international problem that affects social and economic welfare as well as public health. The typical framework for mathematical models involves the classic compartmental model involving ordinary differential equations (ODE) that describe phases of infectious diseases. Mathematical modeling for drug addiction as an infectious disease model can be a novel and unique method of approaching this issue, in particular with the addition of technological rehabilitation as a viable method of drug rehabilitation. This project explores two mathematical models, including one describing the dynamics of addiction through over prescription, and the second describing the dynamics of addiction influenced by social behavior with ODE. In addition, parameters are estimated with AMPL optimization and machine learning; a rural vs. urban prescription model is studied; a basic reproduction number for social model is derived; efforts to support healthcare providers and education as a control for the opioid crisis are also explored; a numerical simulation of each model is implemented with high-order numerical approximation; and a graphical user interface is developed through MATLAB. We hope to validate the mathematical models with real data and incorporate intervention with rehabilitation technology to further enhance the models to be more predictive.